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# The 5G Dual Mandate:

## *Should operators serve both Fixed and Mobile with 5G?*

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**Introduction**

As the mobile industry moves into the 5G, some operators are cautiously optimistic about their prospects -- not just in the mobility market, but also in adjacent markets. Two primary examples include in-home broadband with fixed wireless and industrial IoT. The media imply that 5G technology is making all this possible, but it is arguably the broad spectrum coming online that is driving the market excitement. End of the day, spectrum is the fundamental commodity that drives the mobile industry. In the United States, hundreds of MHz of C-band and about 3,000 MHz of the millimeter wave spectrum bands will come online soon.[1] The new spectrum gives operators like Verizon a chance to launch 5G fixed wireless service in some markets already.

While the expanding spectrum availability portends significantly higher network capacity to serve multiple markets including fixed wireless access, the question remains whether mobile operators should devote a big chunk of the network towards the in-home broadband market with fixed wireless, in addition to core mobility. This *INSIGHT* report explores this "5G dual mandate" question: will mobile operators serve both mobile and fixed broadband market with 5G? More specifically, we examine whether there will be enough capacity on 5G radio network to service both the core mobility and fixed wireless access demands today and in 2025.

Answers to the "5G dual mandate" question will certainly differ by country and region based on a multitude of factors including broadband penetration, competitive dynamics, and other economic factors. In this paper, our analysis focuses on the USA market where fixed-mobile intermodal competition is in the early innings. Primarily mobile operators like Verizon have launched in-home broadband service through 5G fixed wireless--and cable operators now offer mobile services through MVNO. Moreover, we are hearing tier 1 operators increasingly mentioning 5G as a good substitute for fixed broadband technology in some markets. The versatile 5G capabilities and expanding spectrum portfolio are certainly broadening optionality for these operators – whether that is really feasible or practical is another matter.

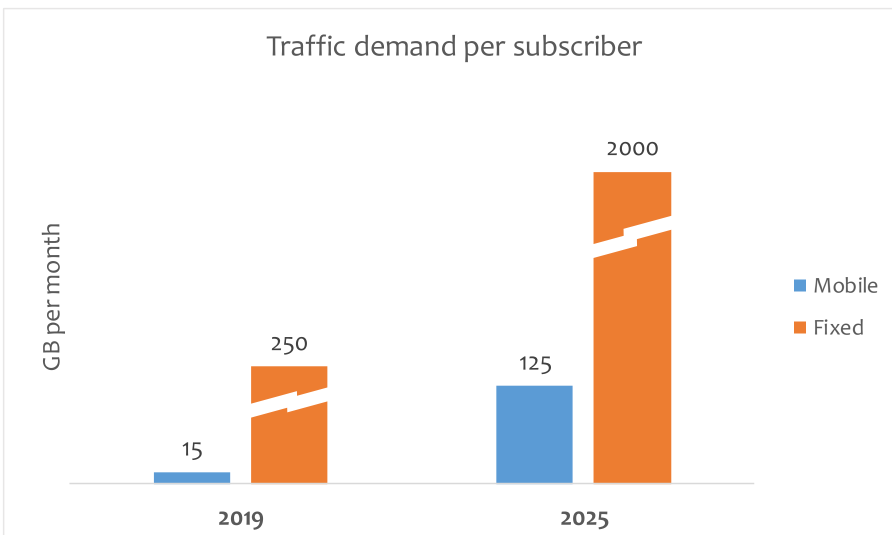
**Mobile and Fixed Demand Projections**

To begin, let's look at the demand side of the supply-demand equation. For mobile data traffic demand, Mobile Experts estimates that average mobile usage will reach 15 GB per

[1] Combined millimeter wave spectrum across the 24, 28, 37, 39, and 47 GHz bands sum up to 5 GHz. About 60% of this amount may be auctioned off by the FCC.

month in key metro markets in the USA in 2019. While our estimate is higher than other notable reports such as Ericsson Mobility Report (which reported 8.6 GB per month of mobile data traffic per active smartphone in North America in 2018)[2] and Cisco VNI (which reported about 9 GB per month from mobile devices globally in 2018)[3], we have purposely taken this aggressive view to reflect the usage in the dense urban pockets where mm-wave services are likely. Other reports provide nationwide average data usage, but in a dense urban market, the usage is likely higher. Assuming 40-50% CAGR growth, we estimate the per-user mobile data usage will rise to 125 GB per month in 2025.

The data traffic growth in fixed broadband is expected to mirror that of mobile demand. Based on the most recent reporting of monthly data usage from a leading U.S. fixed broadband provider[4], we estimate the average fixed broadband usage will reach about 250 GB per month in the U.S. in 2019. Assuming about 40% CAGR growth, we estimate the per-subscriber home fixed broadband usage will reach about 2 TB per month in 2025.




Sources: Mobile Experts

Notes: 1. Fixed traffic demand represents GB/month per subscriber home
2. Mobile traffic demand represents GB/month per individual subscriber

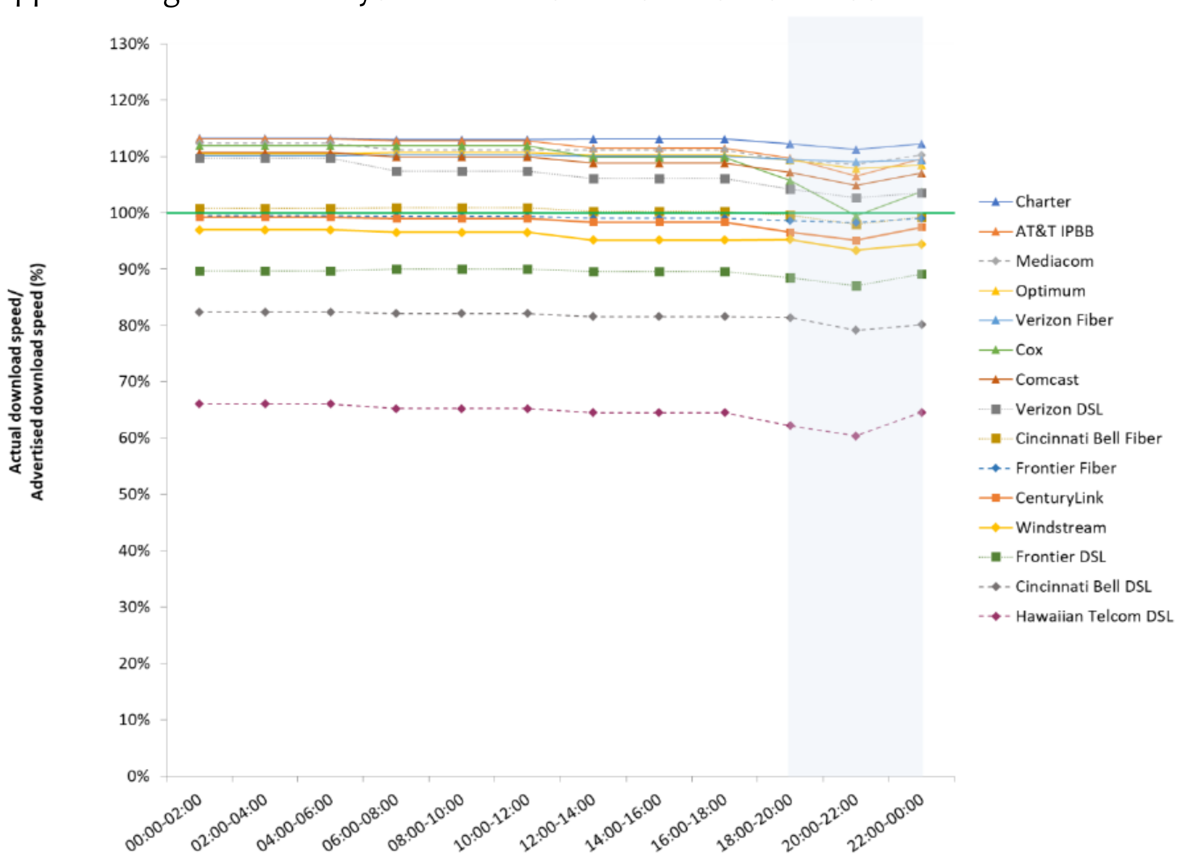
**Figure 1: U.S. fixed and mobile broadband traffic demand projection**

[2] Ericsson Mobility Report, November 2018
[3] Cisco VNI, Global Mobile Data Traffic Forecast Update, 2017-2022
[4] Comcast reported that median broadband usage was 170 GB per month in the second half of 2018

**Fixed and Mobile Usages Differ – But Does That Help?**

A core tenet of using a common access network -- in this case, 5G radio access network – to serve both mobile and fixed broadband services is to take possible advantage of different usage patterns of the two use cases. A simple idea here is to leverage the 5G network to service mobile traffic when fixed broadband use is light and vice versa; thus, hopefully, attain a multiplexing gain by serving both the mobile and fixed data with one network. While the prospect of more efficiently utilizing 5G network resources sounds appealing, the reality doesn't bear that out.

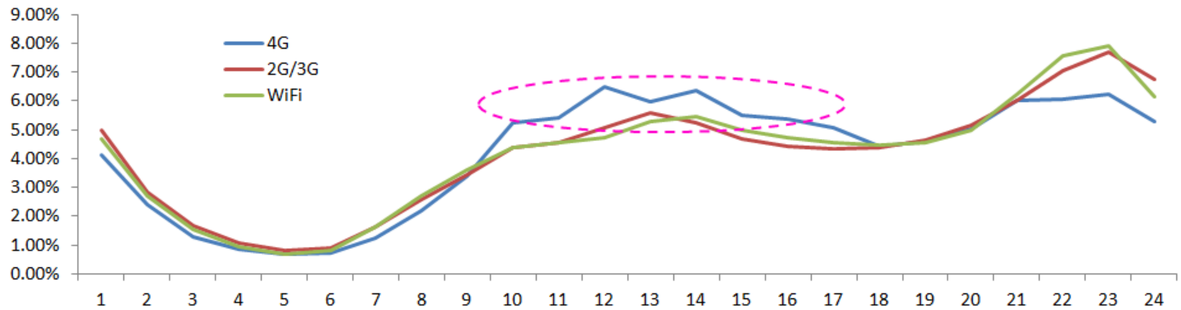
As shown below, the fixed broadband usage is heavily concentrated during the busy-hour period from 7:00 to 11:00 pm. The below figure highlights network contention during the busy hour period (highlighted in gray) where the actual download speeds are below that of advertised speeds – due to network congestion from multiple subscribers all wanting to get online. This result is not surprising since most home broadband use happens at night when everyone is back home from work or school.




Sources: FCC

**Figure 2: Hourly fixed broadband actual vs. advertised speeds**

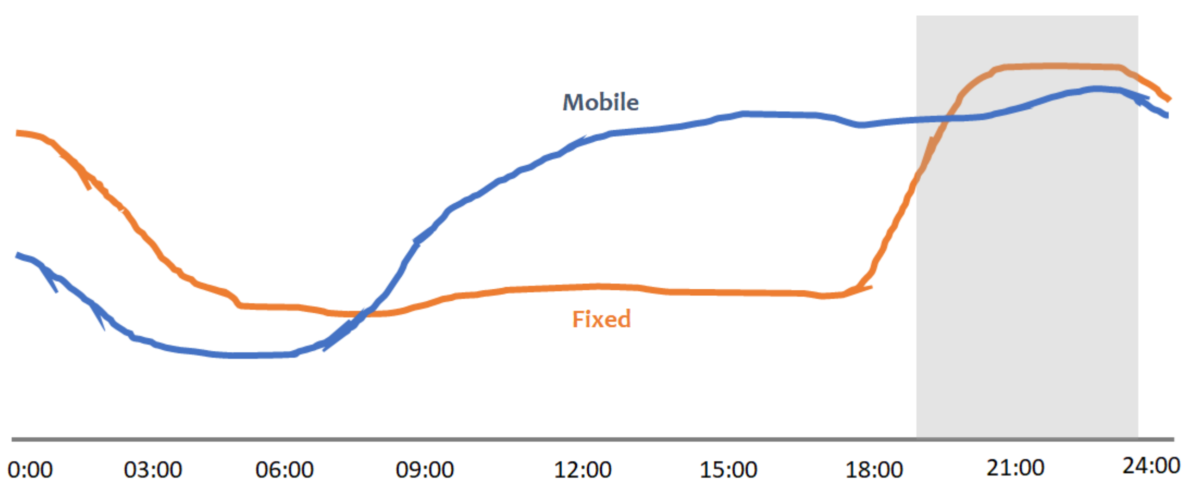
While fixed broadband traffic busy-hour period is confined to the four- to five-hour period at night, the busy-hour period is a myth in the mobile broadband case. With data dominating mobile traffic profile (versus voice), the hourly traffic distribution shows a high usage level pretty much steady throughout the whole day -- except from 12:00 to 6:00 am when people are asleep. As shown below, the daily mobile traffic profile indicates a steady use during waking hours from 9 am to midnight. There isn't much "downtime" in mobile data use on mobile networks these days.




Sources: Huawei Mobile Broadband Review

**Figure 3: Mobile data usage in a day**

As illustrated below, there isn't much opportunity to "multiplex" 5G network utilization of mobile and fixed broadband services. Based on daily traffic profiles, the 5G network must be sufficiently provisioned to handle the combined traffic demands of fixed and mobile services during the busy-hour period from 7:00 pm to midnight.




Sources: Mobile Experts

**Figure 4: Hourly Fixed and Mobile Traffic Distribution (Illustration)**

### Busy-Hour Traffic Demands in Urban and Suburban Markets

With the acknowledgment that there is not much opportunity for a multiplexing gain from servicing mobile and fixed data on 5G network, the next step is to identify peak busy-hour traffic from both mobile and fixed demand, to see how much radio capacity is needed to meet growing traffic demand. Assuming that 10% of daily traffic occurs in a busy-hour, the monthly data usages as shown in Figure 1 can be translated into average busy-hour traffic per subscriber as shown below for "urban" and "suburban" cases as shown below.

| | Urban[6] | | Suburban[7] | |
|---|---|---|---|---|
| | **2019** | **2025** | **2019** | **2025** |
| **Subscribers (per km²)** | | | | |
| Housing density | 2,500 | 2,500 | 1,000 | 1,000 |
| No. of subscriber homes[1] | 750 | 750 | 300 | 300 |
| Population density | 6,750 | 6,750 | 2,700 | 2,700 |
| No. of subscribers[2] | 2,363 | 2,363 | 945 | 945 |
| **Mobile demand (Mbps/km²)** | | | | |
| GB per month per subscriber | 15 GB | 125 GB | 12 GB | 70 GB |
| Busy-hour traffic per subscriber[3] | 0.1 | 0.9 | 0.1 | 0.5 |
| Total mobile traffic | **263** | **2,188** | **84** | **490** |
| **Fixed demand (Mbps/km²)** | | | | |
| GB per month per subscriber | 250 GB | 2,000 GB | 250 GB | 2,000 GB |
| Busy-hour traffic per subscriber | 1.9 | 14.8 | 1.9 | 14.8 |
| Total fixed traffic | **1,389** | **11,111** | **556** | **4,444** |
| **Total demand (Mbps/km²)** | **1,652** | **13,299** | **640** | **4,934** |
| No. of 5G mmw cells (per km²)[4] | 5 | 5 | 5 | 5 |
| **Demand per 5G cell (Mbps)[5]** | **330** | **2,660** | **128** | **987** |

Source: Mobile Experts

Notes:
1. Assume 30% market penetration of in-home broadband with 5G fixed wireless access
2. Assume 35% of the population in the area are subscribers
3. Assume 10% of daily traffic occurs in a busy-hour
4. Assume a 5G millimeter wave radio has a 250-meter range
5. Assume traffic demand is uniformly distributed in the 1 km² footprint (among 5G radios)
6. Urban housing density is representative of Cambridge, MA or Marina del Rey, CA
7. Suburban housing density is representative of Orange County, CA

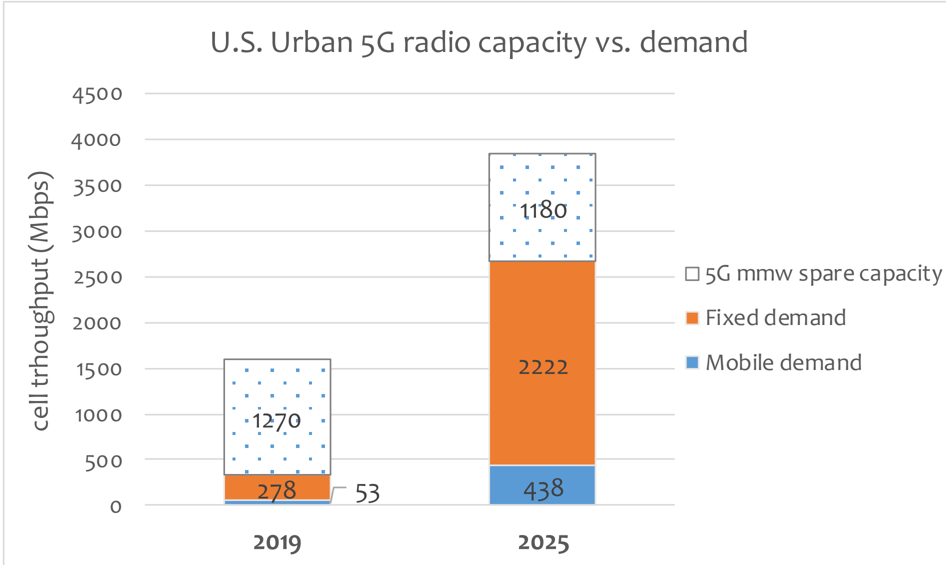
**Figure 5. Peak busy-hour total demand per 5G millimeter wave cell**

It should be noted that the mobile and fixed traffic demands highlighted in the table above are based on a 1 km² footprint. The total mobile and fixed traffic demands are calculated by multiplying the busy-hour traffic per subscriber by the number of individual subscribers and subscriber homes respectively. Assuming that a 5G millimeter wave radio cell can reach 250 meters in range, we assume that there are five 5G radio cells in the 1 km2 footprint. We simply divide the total combined mobile and fixed traffic demands by the number of 5G radio cells to determine the total traffic demand per radio. As highlighted in the table, a 5G radio must be capable of handling up to 2.7 Gbps of cell throughput in 2025 to handle combined mobile and fixed broadband traffic in urban settings, and up to 1.1 Gbps of cell throughput in suburban settings to meet the projected combined traffic demand.

**Total Demand vs. 5G Capacity**

With the combined mobile and fixed traffic demands per 5G radio cell determined (Figure 5), we need to see whether 5G radio networks can meet the projected traffic demands. For our analysis, we focus on 5G millimeter wave small cells only, comparing the new 5G capacity to expected demand. With some leading operators such as Verizon already owning over 1000 MHz-pop in millimeter wave spectrum[5], we have assumed that a 5G radio with 400MHz of spectrum can yield about 1,600 Mbps cell throughput in 2019 and over 3,800 Mbps of cell throughput in 2025 with 800 MHz of spectrum deployed with additional incremental efficiency gains from improvements in NR and massive MIMO in 2025.

[5] Verizon holds population-weighted average of over 400 MHz of the 28 GHz spectrum and over 500 MHz of the 39 GHz spectrum through XO and Straightpath acquisitions.

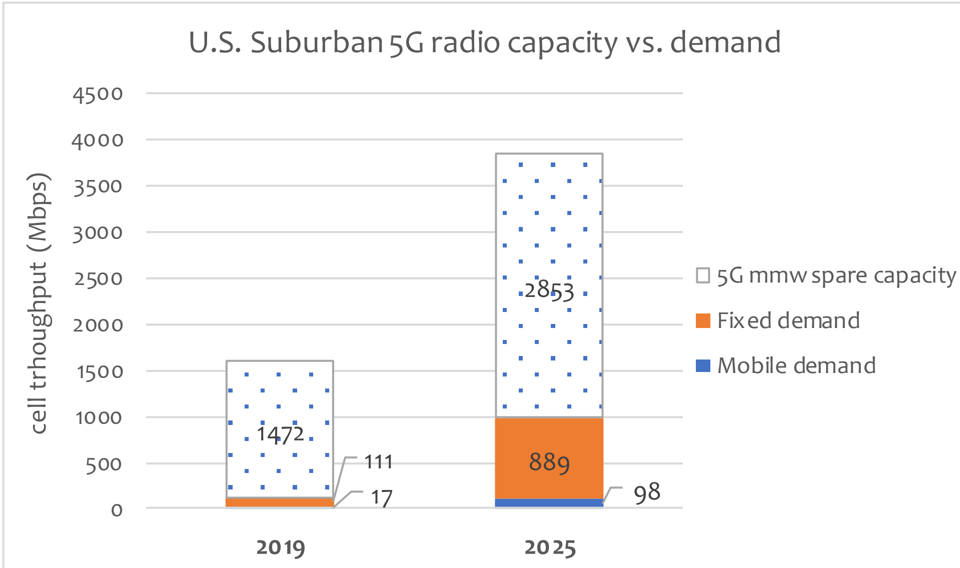



Sources: Mobile Experts

Notes:
1. 400 MHz of millimeter wave spectrum deployed in 2019
2. 800 MHz of millimeter wave spectrum deployed in 2025
3. Five 5G millimeter wave radios deployed in the 1 km^2 footprint

**Figure 6: USA Urban Mobile and Fixed Demand vs. 5G mmW radio capacity**

Based on projected mobile and fixed traffic demands in 2019 and 2025, we see that a 5G millimeter wave radio can sufficiently meet the projected mobile and fixed traffic demands and have spare capacity left over in the urban case.




Sources: Mobile Experts

Notes:
1. 400 MHz of millimeter wave spectrum deployed in 2019
2. 800 MHz of millimeter wave spectrum deployed in 2025
3. Five 5G millimeter wave radios deployed in the 1 km^2 footprint

**Figure 7: USA Suburban Mobile and Fixed Demand vs. 5G mmW radio capacity**

With its lower demand profile, the suburban case is even more compelling with ample spare cell capacity left over on the 5G millimeter wave radios after servicing both mobile and fixed data traffic.

**Is "Mobile" Capacity Enough?**

At first glance, the 5G radio network appears to have ample capacity to meet the growing traffic demands from both mobile and fixed broadband services in both urban and suburban cases – with spare capacity shown in Figures 6 and 7. Even under the demanding urban case in 2025, our calculations show that a 5G millimeter wave radio with 800MHz of spectrum deployed would have over 30% of the 3840 Mbps cell throughput capacity left over after servicing about 450 Mbps of mobile traffic demand and over 2200 Mbps of fixed broadband demand. The key question remains -- does the remaining radio capacity excluding the fixed broadband demand provide acceptable mobile user experience? In other words, would it provide good mobile speeds that users expect?

A mobile user's speed depends largely on the number of users sharing the radio resource, and relative location to the radio cell site. During busy times when many users are contending for the radio cell capacity, the user experience can vary dependent on signal quality. A user closer to the radio with a good line of sight would experience a high throughput while a user at cell edge would experience a low throughput. The average cell throughput represents the radio capacity of users in good and bad link conditions. We use the term, "busy mean" cell throughput, to represent this full load condition during the busy hour. Based on an NGMN simulation study[6], we estimate that the average user speed is about 1/6th of the peak radio capacity. Thus, the 5G millimeter wave radio cell throughput capacity minus the capacity needed to serve the fixed broadband demand in Figures 6 and 7 can be translated into expected mobile speeds as shown below.

| (units in Mbps) | Urban | | Suburban | |
|---|---|---|---|---|
| **Per 5G mmw radio** | **2019** | **2025** | **2019** | **2025** |
| 5G mmW cell capacity | 1,600 | 3,840 | 1,600 | 3,840 |
| (minus) Fixed demand | 278 | 2,222 | 111 | 889 |
| Net radio capacity | 1,322 | 1,618 | 1,489 | 2,951 |
| Busy-mean mobile speeds | **220** | **270** | **248** | **492** |
| Mobile speed improvement | | **22%** | | **98%** |

Source: Mobile Experts

**Figure 8. Expected Mobile Speeds after Servicing Fixed Broadband**

The above table illustrates that there is enough radio capacity to service mobile traffic demand after servicing fixed broadband demand. However, the expected mobile speed increases marginally from 220 Mbps in 2019 to 270 Mbps in 2025 in the urban case – only 22% improvement in 6 years! (In contrast, the expected mobile speed almost doubles from around 250 Mbps in 2019 to about 500 Mbps in 2025 in the less-demanding suburban case -- which is what users would probably expect.)

In a competitive mobile market in which users are used to a continual increase in mobile speeds and operators espouse faster speeds in marketing campaigns, the marginal 20% increase in mobile speeds in 6 years may be deemed not good enough if competitors offer noticeably higher mobile speeds. The user's perception will depend greatly upon any new applications that arise in the next five years. Today, HD Video and even 4K Video streaming work fine at speeds below 30 Mbps, and a speed boost to 100 Mbps may not change the user's perception of quality. However, if new VR or faster movie

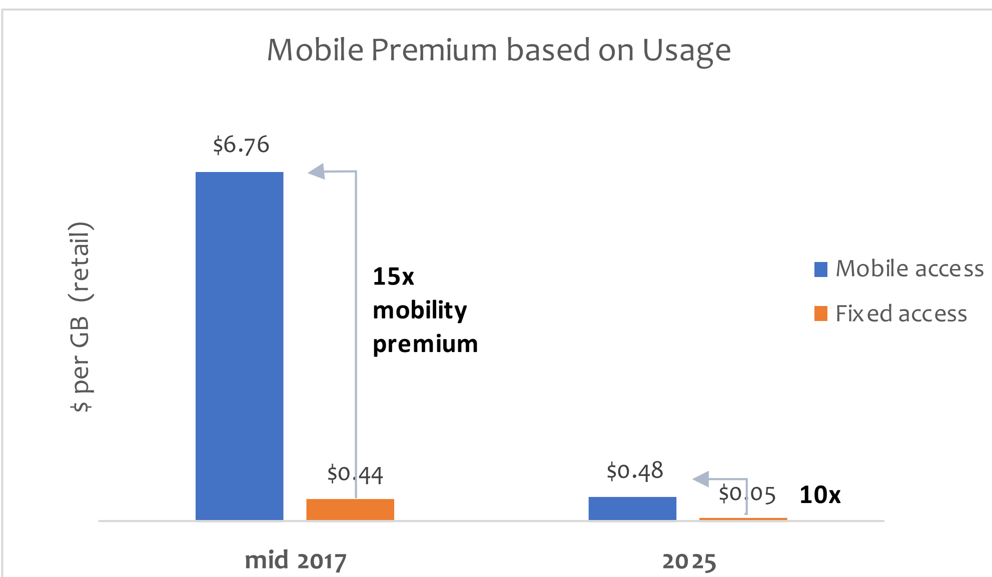
[6] NGMN Small Cell Backhaul Requirements, June 2012. This white paper showcases the mean to peak user plane traffic per cell ranges from 1/5th to 1/7th depending on different LTE configurations. We use this as a rough estimate in our calculations.

download applications begin to require speeds in the 500 Mbps range, for example, a slow increase in data speed could be perceived as a problem.

Even if 5G networks can service the total volume of mobile and fixed traffic, operators must consider user experience. We caution mobile operators to focus on coverage and capacity, because the consumer experience depends on those factors since the user speeds and network capacity are the two sides of the same coin of a shared network.

**Mobility Premium – Consideration in Fixed and Mobile Data Convergence on 5G**

If a gigabyte (GB) of data for in-home broadband (via fixed wireless) or a GB of data for mobility is the same GB over the 5G network, a business decision may hinge upon how much revenue an operator can be derived from each GB of data delivered – whether that data transport was to a CPE gateway for in-home broadband or to a mobile device for mobility service. We have discussed the *mobility premium* concept – i.e., differential retail pricing on a per-GB basis between fixed and mobile broadband services – as a gauge to track the fixed-mobile competition and a possible indicator of wireless substitution trend. Referencing our previous work on this topic[7], we surmise that the mobility premium will likely continue (assuming no dramatic shift in the intermodal competition between mobile and cable players) in 2025 as shown below.




Source: Mobile Experts

**Figure 9. Mobility premium will ten times higher in 2025**

[7] Expert INSIGHT (MEXP-RAN-17-EI4), "*Mobility Premium – How will it change in a 5G world?*", August 2017

Operators will be able to charge 10x more to deliver a GB of *mobile* data vs. *fixed* data even though the underlying transport network may be a 5G wireless network. If this *mobility premium* condition persists in the future, an operator decision to utilize 5G network resources for both mobile and fixed traffic – even if the throughput capacity can sufficiently handle combined data traffic – may hinge upon how that may impact the user experience on mobility services. Knowing that each GB of *mobile* data is worth 10x more than *fixed*, it is logical for operators to prioritize mobility service over fixed wireless, and user experience in terms of mobile speeds and other factors will certainly rise to the top.

**Conclusions**

A 5G network with a big swath of spectrum promises a huge influx of network capacity, enabling operators to pursue not only the main mobility market but adjacent markets in fixed broadband and enterprise segments. We believe that 5G millimeter wave radio networks can handle the projected mobile and fixed data volume out to 2025, with up to 800MHz of millimeter wave spectrum deployed in urban markets, but we believe there are some risks for operators go down this path:

- First, dedicating a sizable 5G radio capacity towards consumptive fixed wireless service leaves less capacity for mobility service – especially if the LTE network that backs up 5G fixed wireless is used for FWA data. Allowing FWA to gobble up capacity could negatively impact user mobile speeds, especially in dense urban markets.
- Secondly, operators can likely charge as much as 10x more for mobile vs. fixed data. In this scenario, using a high-cost mobile network to serve low-revenue fixed data could be less profitable.
- Lastly, there is a significant opportunity cost of opting for fixed wireless vs. other potentially higher-revenue producing opportunities in enterprise services such as massive IoT and industrial automation. In terms of revenue per GB, industrial applications could be the most attractive opportunity of all.

5G and huge chunks of spectrum in both the C-band and millimeter wave bands bring myriad opportunities for mobile operators. While in-home broadband via fixed wireless offers a tangible near-term market opportunity, operators must carefully consider long-term consequences on their mobility services. Also, they need to weigh the opportunity cost of taking on this consumer market opportunity vs. enterprise market opportunities which may offer higher returns.